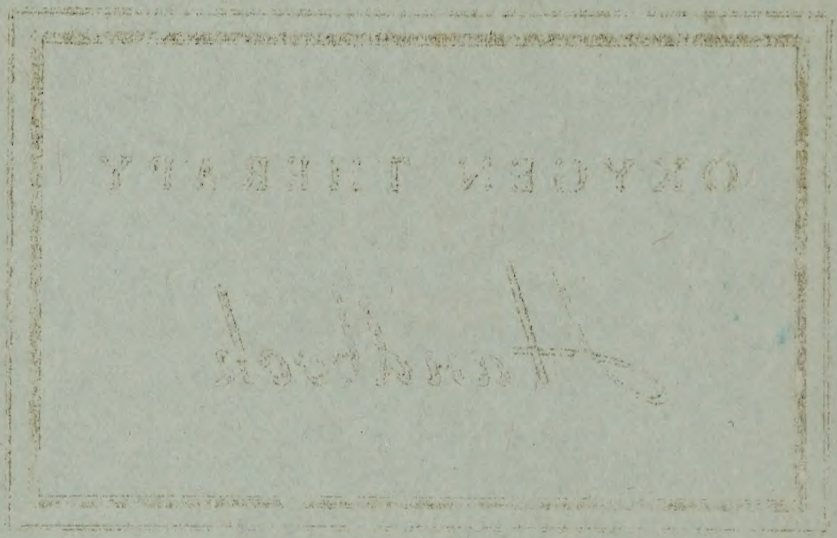
OXYGEN THERAPY

Handbook



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OXYGEN THERAPY

Handbook

THE LINDE AIR PRODUCTS COMPANY

UNIT OF UNION CARBIDE AND CARBON CORPORATION

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The Linde Air Products Company

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THE LINDE AIR PRODUCTS COMPANY, a Unit of Union Carbide and Carbon Corporation, has been collaborating for several years with leading medical authorities in their investigations of the therapeutic value of oxygen. As a result, Linde oxygen in standard industrial-size cylinders and suitable for therapeutic purposes, was made available to the medical profession to meet the increasing demand for large quantities of high-purity oxygen at moderate prices.

The Linde process obtains oxygen from the atmosphere by fractional distillation and rectification of liquid air. Linde oxygen U.S.P., as produced by The Linde Air Products Company, is available throughout the nation from 67 plants, 66 warehouses, and numerous distributors.

Every Linde oxygen cylinder carries the notation "This cylinder contains Linde oxygen U.S.P." which indicates that the oxygen contained in it—whether the cylinder is obtained direct from a Linde plant or warehouse, or from the stock of a nearby industrial user—conforms to the requirements of the United States Pharmacopoeia, 12th Revision.

Note — The word "Linde" is a trade-mark of The Linde Air Products Company.

THIS CYLINDER
CONTAINS
LINDE
U.S.P.
OXYGEN

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Introduction

OXYGEN therapy is the administration of oxygen-enriched atmospheres—air to which extra oxygen has been added—for the relief of oxygen-want. When oxygen therapy is prescribed it is important to make certain that the patient receives a sufficiently high concentration of oxygen to overcome his degree of oxygen-want (anoxia).

It is the purpose of this booklet to present in concise form information on the technical and mechanical phases of oxygen therapy. This includes a consideration of such factors as the care and handling of oxygen cylinders and regulators, and the proper operation and maintenance of oxygen therapy apparatus.

Effective oxygen therapy, however, was not possible until recent years because suitable mechanical equipment did not exist and large quantities of sufficiently pure oxygen were not available at moderate prices. Much of the present success is due to new developments in equipment for administering oxygen in proper concentrations under controlled atmospheric conditions, and the availability at industrial prices of Linde oxygen U.S.P., as distributed in large industrial-size cylinders.

During the past few years clinical studies and scientific research in oxygen therapy have been constantly broadening. Fundamental factors underlying oxygen therapy have been scientifi-

cally studied by a number of investigators, and methods have been developed for the practical use of the information thus obtained. As a result of these investigations, *the value of early and adequate oxygen treatment* in cases where oxygen-want is present has been established. Physicians now prescribe oxygen therapy as a regular treatment, and hospitals are now equipped to administer oxygen.

Various types of equipment have been developed for oxygen therapy. Face masks, nasal inhalers, and catheters probably provide the simplest means of administration. Tents that enclose the upper half of the patient's body combine the benefits of air conditioning with a therapeutic concentration of oxygen. Oxygen rooms, of which there are comparatively few, provide the same atmospheric conditions as the tent but to a more exact degree, and in addition allow the patient the advantages of unhampered nursing service.

Today, the physician has at his command a great amount of clinical evidence of the value of oxygen therapy, and satisfactory equipment for its administration. The following pages summarize the more important current practices in operating oxygen therapy equipment.

Oxygen Therapy Requirements

In order to make the administration of oxygen for therapeutic purposes most effective and most economical, four requirements must be met.

The first requirement is a supply of U.S.P. oxygen. Large cylinders of about 244-cubic-foot capacity at standard industrial prices are preferable.

The second is a safe and dependable regulator that will deliver the oxygen to the administering equipment at the desired constant rate of flow.

Third, proper administering apparatus that is efficient in operation and sturdy in construction must be available.

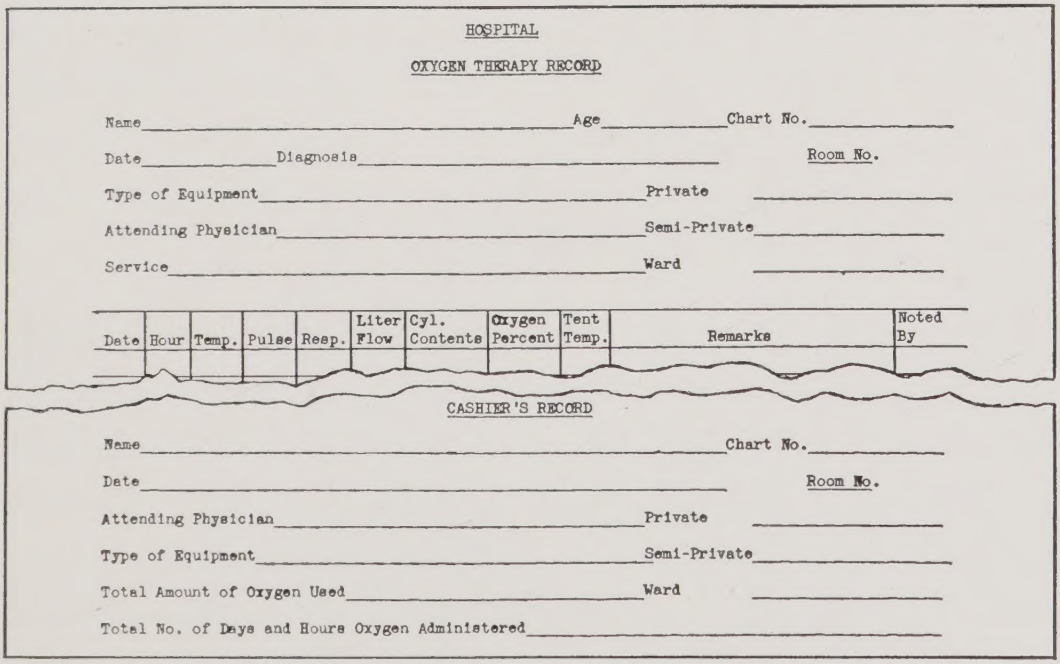
Fourth, and most important, all persons concerned must have a thorough knowledge of the handling and operation of oxygen cylinders, regulators, and oxygen administering apparatus.

Fulfillment of the first three requirements is a matter of standard routine in that it calls merely for the purchase of adequate supplies and equipment. The fourth requirement, however, calls for knowledge concerning the mechanical phases of oxygen therapy.

This essentially means knowing the working principles of the equipment used, and the procedure of setting it up and keeping it functioning correctly. Also, to be certain that a therapeutic concentration of oxygen is being administered in tents, rooms, or chambers, it is necessary to know how to make an analysis of the atmosphere being administered to the patient. Study of the manufacturer's instructions for each piece of apparatus and a little practice make the acquisition of this knowledge easy, and the effective administration of oxygen therapy becomes a routine procedure.

In the hospital, creation of an oxygen therapy department has proved to have distinct advantages. Such a department is usually under the supervision of a physician who is especially interested in the physiology of respiration and is familiar with the mechanics of administering oxygen. This plan is being increasingly adopted.

Suitable charts aid in keeping departmental records.



HOSPITAL

OXYGEN THERAPY RECORD

Name_____ Age_____ Chart No._____

Date_____ Diagnosis_____ Room No.

Type of Equipment_____ Private _____

Attending Physician_____ Semi-Private_____

Service_____ Ward _____

Date	Hour	Temp.	Pulse	Resp.	Liter Flow	Cyl. Contents	Oxygen Percent	Tent Temp.	Remarks	Noted By

CASHIER'S RECORD

Name_____ Chart No._____

Date_____ Room No.

Attending Physician_____ Private _____

Type of Equipment_____ Semi-Private_____

Total Amount of Oxygen Used_____ Ward _____

Total No. of Days and Hours Oxygen Administered_____

Oxygen Supply

In nearly every community in the country, U.S.P. oxygen is available, through producing plants, warehouses, or distributors. There is no necessity, therefore, for keeping more than 3 or 4 days' supply on hand. In an unforeseen emergency, a supply of oxygen can be obtained from the nearest welding shop, automotive repair shop, or industrial plant. A continuous record should be kept of the number of full, part-full, and empty cylinders on hand.

The large-size 244-cubic-foot oxygen cylinders most frequently used for oxygen therapy are filled to a pressure of 2,200 pounds per square inch at a temperature of 70 degrees Fahrenheit. If a cylinder is exposed to an abnormally high or low temperature, the pressure of the oxygen within the cylinder will rise or fall correspondingly. This is a natural phenomenon. The quality of the oxygen is not affected, and the net contents remain the same.

Oxygen cylinders should not, however, be stored or placed near such heating equipment as boilers, furnaces, steampipes, sterilizers, autoclaves, laundry apparatus, stoves, or radiators. This is because the heat from such objects might cause an excessive rise in the pressure of the oxygen within the cylinders. Oxygen cylinders are equipped with safety disks or plugs that automatically open and

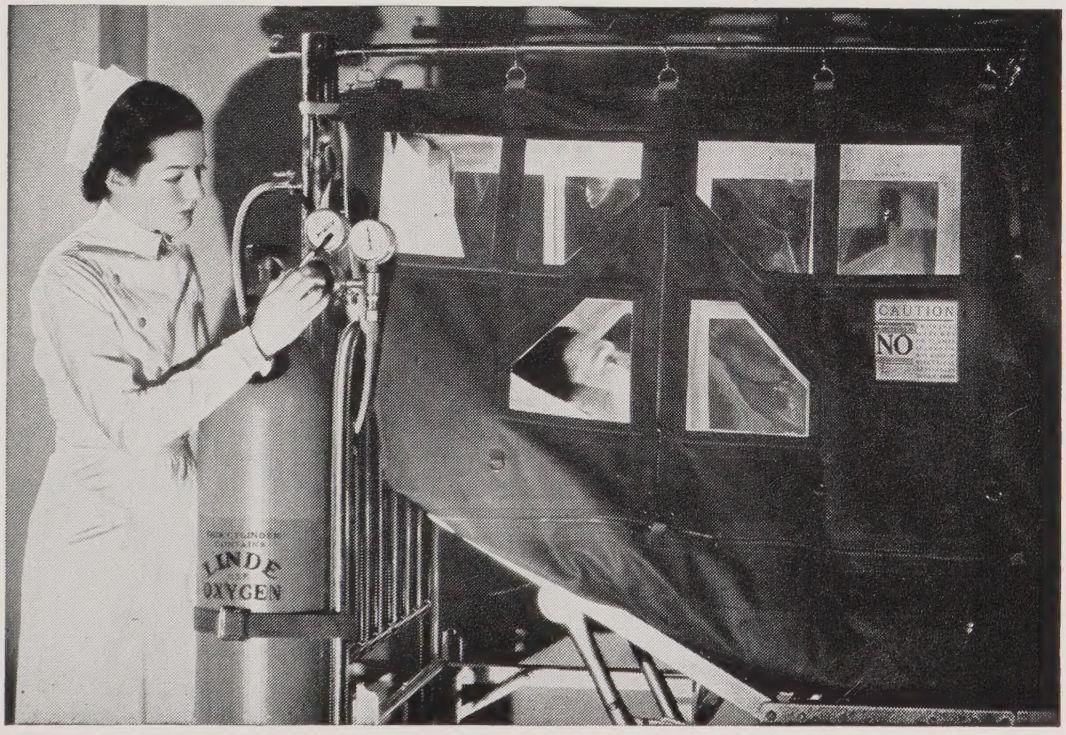
release the oxygen before such a pressure rise becomes dangerous; but if this happens, all the oxygen in the cylinder is lost.

Oxygen cylinders should not be stored near oil, grease, or other flammable material.

Whenever an oxygen cylinder is placed in service, it should be used in an upright position. It should be strapped to the bedpost or, if this is not convenient, placed in a corner or other location where it will not be bumped or knocked over. When an oxygen cylinder falls there is always the danger of someone being hurt and the probability of apparatus being broken, which would necessitate repair or replacement.

When the oxygen in a cylinder has been used up, the cylinder

Cylinders should be positioned and fastened so they cannot be knocked over.



should be plainly marked "Empty" and stored separately so that it will not be mistaken for a full cylinder. *All empty cylinders should be returned promptly to the oxygen manufacturer or to the distributing station.*

An uninterrupted supply of oxygen is, of course, vital to the successful administration of oxygen therapy. It is important, therefore, that the technician have some idea as to how long the supply of oxygen in a given cylinder will last so that preparations may be made in advance to substitute a fresh cylinder as soon as necessary. Standard 244-cubic-foot oxygen cylinders can be readily handled by nurses who have received proper instructions and equipment.

Full cylinders should always be stored separately from empties.

The chart below indicates the approximate hours of service that a standard 244-cubic-foot cylinder of Linde oxygen U.S.P. will give when used at various rates of flow.

APPROXIMATE REMAINING HOURS OF SERVICE IN STANDARD 244-CU.-FT. CYLINDERS OF LINDE OXYGEN U.S.P.

(For 122-cu.-ft. Cylinders, Divide Hours of Service by 2)

Flow Indicator	*Cylinder Contents				
	Full Cylinder	*Cylinder—Contents—Gauge Reading			
Rate of Flow in liters per Min.	*244 cu. ft. 2,200 lb. 6,900 liters*	*"FULL" 220 cu. ft. 2,000 lb. 6,000 liters*	*"¾" 165 cu. ft. 1,500 lb. 4,500 liters*	*"½" 110 cu. ft. 1,000 lb. 3,000 liters*	*"¼" 55 cu. ft. 500 lb. 1,500 liters*
2	57½ hours	50 hours	37½ hours	25 hours	12½ hours
3	38¼ "	33 "	24¾ "	16½ "	8¼ "
4	28¾ "	25 "	18¾ "	12½ "	6¼ "
5	23 "	20 "	15 "	10 "	5 "
6	19 "	16½ "	12¼ "	8¼ "	4 "
7	16¼ "	14¼ "	10½ "	7 "	3½ "
8	14¼ "	12½ "	9¼ "	6¼ "	3 "
9	12¾ "	11 "	8¼ "	5½ "	2¾ "
10	11½ "	10 "	7½ "	5 "	2½ "
12	9½ "	8¼ "	6 "	4 "	2 "
15	7½ "	6½ "	4¾ "	3¼ "	1½ "

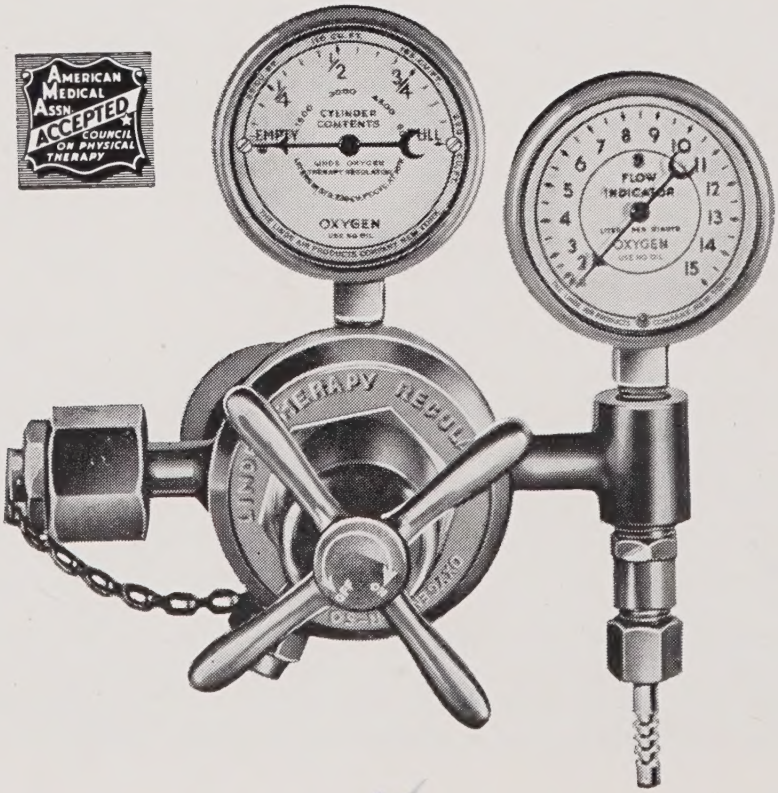
* Since April 15, 1942, Linde oxygen cylinders have been filled with 244 cu. ft. of oxygen under a pressure of 2,200 lb. per sq. in., instead of 220 cu. ft. of oxygen under a pressure of 2,000 lb. per sq. inch. Therefore, when determining the hours of service for a full 244 cu. ft. cylinder from which no oxygen has been drawn, use the first column. As soon as the needle on the CYLINDER-CONTENTS gauge has swung back to the position previously indicating the cylinder to be FULL, use the other columns to determine remaining hours of service.

Examples—Full cylinder, originally containing 244 cu. ft. of oxygen, flowing at rate of 8 liters per minute should last approximately 14¼ hours. A cylinder on which the contents gauge shows "one-half full" flowing at rate of 2 liters per minute should last approximately 25 hours.

Oxygen Regulators

As has been noted, the oxygen in a full cylinder is under a pressure of 2,200 pounds per square inch. It is necessary to reduce and control this pressure before the oxygen can be administered to a patient. Approved oxygen regulators are available for this purpose. *Never attempt to administer oxygen without a regulator.*

This is a standard two-stage hospital-type oxygen regulator.



The oxygen regulator has two important functions: First, to reduce the pressure of oxygen from that in the cylinder to the comparatively low pressure at which it is used; and, second, to insure a steady, even flow of oxygen at the predetermined rate. The rate of flow can be set as desired by means of the flow-adjusting screw of the regulator. The flow gauge on most oxygen therapy regulators is calibrated in liters per minute.

It is preferable to use a regulator of the two-stage automatic re-

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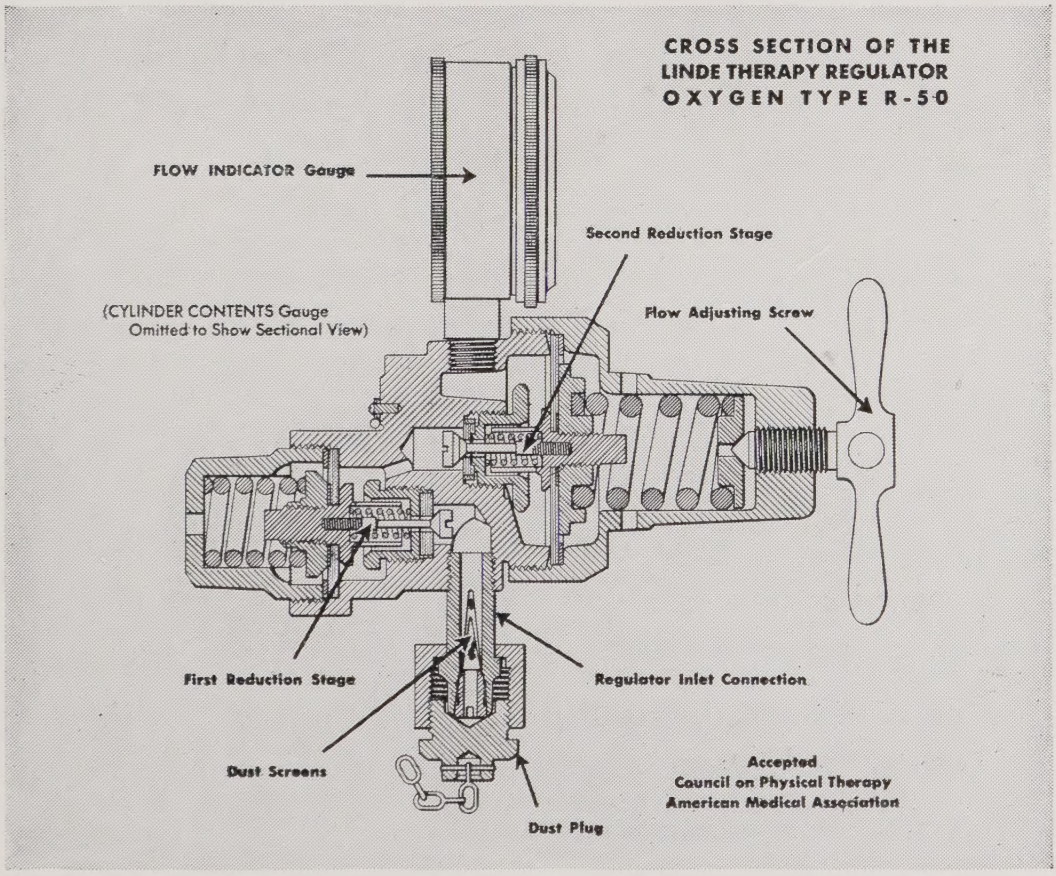
The two-stage regulator is actually two regulators in one, combined to provide more accurate control of oxygen flow.



duction type, which is actually two regulators in one. High-pressure oxygen from the cylinder enters the first stage, where its pressure is automatically reduced before entering the second, or regulating, stage. In this way full cylinder pressure is prevented from straining the delicate mechanism of the second stage by which the flow is accurately controlled. Each regulator is accompanied by a set of operating instructions and will give long and satisfactory service if used in accordance with these instructions.

The following rules should be observed:

1. Before an oxygen regulator is handled, any oil or grease on the hands should be thoroughly removed by washing with soap and water.
2. Before the regulator is attached to a cylinder of oxygen, the cylinder valve should be "cracked" (opened slightly and quickly closed) to blow out any dust that may have lodged in the opening.
3. After the regulator is attached to the cylinder, always make absolutely certain that the flow-adjusting screw of the regulator is turned to the left (OFF) until loose before opening the valve of the oxygen cylinder.
4. The cylinder valve should be opened slightly and slowly at first. As soon as the pointer on the cylinder-contents gauge of the regulator stops moving, the cylinder valve should be opened completely.
5. Turn the adjusting screw to the right (ON) until oxygen flows through the regulator at the desired rate in liters per minute as indicated on the flow-indicator gauge.
6. When the regulator is not in use and not attached to the cylin-

der, always close the cylinder inlet connection of the regulator with the dust plug, and make sure that the flow-adjusting screw is turned to the left (OFF) until loose.

7. *Never use oil or grease on an oxygen regulator, cylinder valve, or any oxygen connections.*

Some oxygen therapy regulators do not have flow-adjusting screws. A predetermined pressure is delivered by the regulator mechanism to a hollow, transparent tube that contains a float (see illustration of L-14 flowmeter on page 19). The position of the

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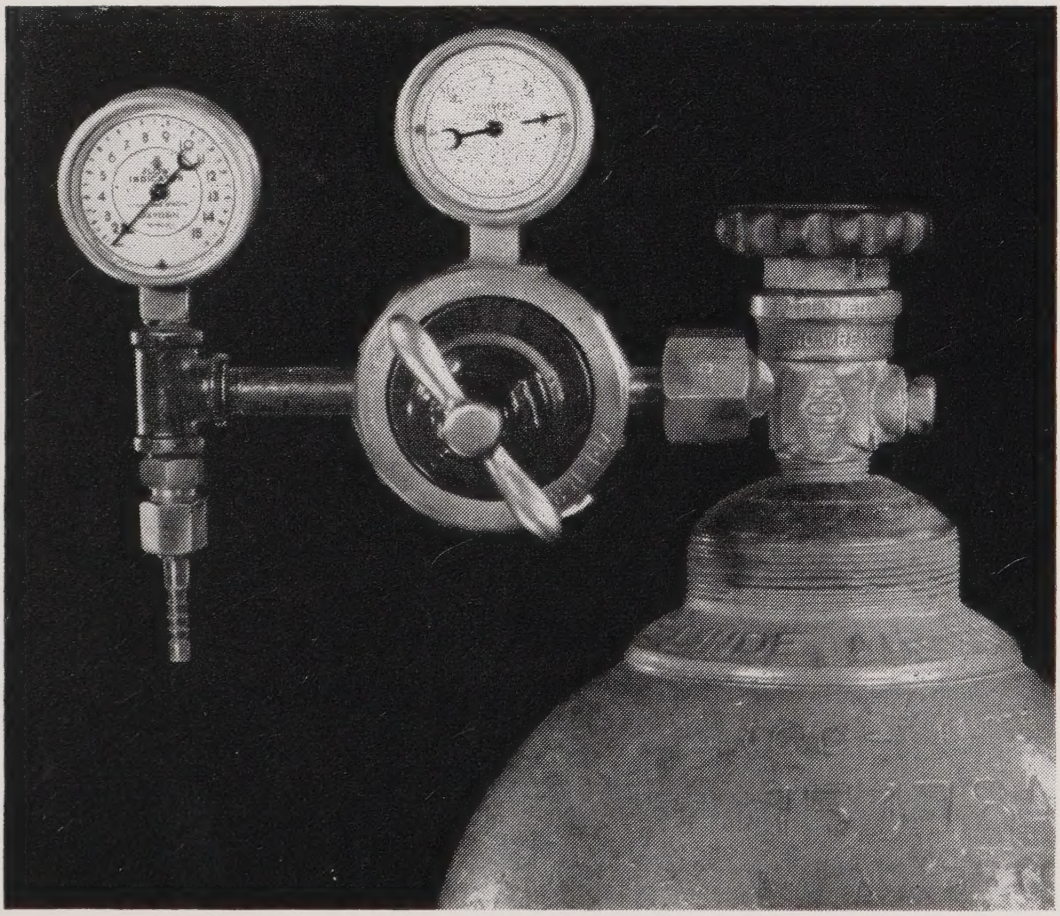
Basic equipment for oxygen administration consists of an oxygen cylinder and a regulator.



float in the tube indicates the rate, in liters per minute, at which oxygen is being delivered. The rate of flow is controlled by a needle valve and *it is important that this needle valve be closed before opening the cylinder valve.*

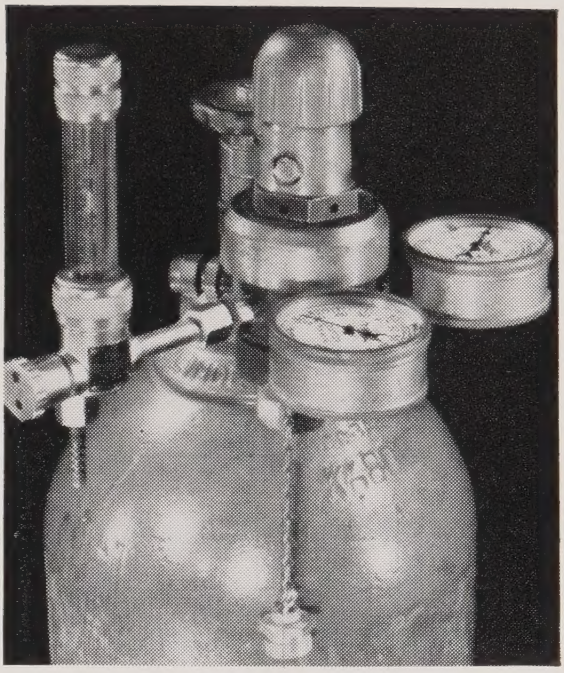
A cylinder of oxygen and an oxygen regulator constitute the basic equipment for giving oxygen. Having this much to start with, oxygen therapy can be administered by any desired type of apparatus.

Oxygen Therapy Flowmeter

The Linde oxygen therapy flowmeter, Type L-14, is designed primarily for measuring the flow of oxygen from the wall outlets of an oxygen piping system (see page 48). The device is light in weight and readily portable. It is calibrated for oxygen flows of from ½ liter per minute up to 15 liters per minute, but will deliver much higher flows, if desired, for tent purging.

The L-14 (see page 19) provides a means whereby the accuracy of standard hospital-type regulators can be checked. Connect the inlet of the L-14, either directly or by means of rubber tubing, to the outlet of the regulator to be tested. Open the valve of the L-14 wide. Check the regulator readings against the L-14 readings. *Always be sure the L-14 is in a vertical position and the outlet unobstructed.*

In addition to the above recommended uses, the Linde oxygen therapy flowmeter, Type L-14, can be used for other purposes. For example, by attaching the L-14 to the outlet of a standard welding-type oxygen regulator, the flow of oxygen from the regulator can be controlled and measured in liters per minute. At times it may



This welding regulator, with a flowmeter attached to its outlet connection, can now be used for oxygen therapy.

be desirable to place the oxygen cylinder and regulator outside the patient's room, at the same time allowing for the control of the liter flow at the bedside. This can be accomplished by clamping an L-14 to the bed and connecting the inlet of the L-14 to the outlet of the regulator by means of a long piece of standard welding hose. The regulator outside the room is adjusted to deliver oxygen through the hose to the inlet of the L-14 at a constant pressure of approximately 20 pounds per square inch, and the flow of oxygen to the patient is controlled by adjusting the valve on the L-14. This system has been used satisfactorily in hospital nurseries and in private homes.

Oxygen Therapy Apparatus

Oxygen therapy apparatus has been designed with three objects in view. First and most important, it must be capable of continuous administration of a therapeutic concentration of oxygen; second, it should provide for the patient's comfort; and third, it must be safe and economical in operation.

Oxygen therapy apparatus is available in the following general types:

1. Face masks
2. Intranasal oropharyngeal catheters
3. Nasal equipment
4. Oxygen tents (including open-top tents)
5. Helium-oxygen apparatus
6. Oxygen chambers.

Choice of the type of equipment by which oxygen is to be administered is important. Obviously this choice depends upon the equipment available, but selection of the available types may have an important bearing on the effectiveness of the treatment. If moderate concentrations—40 to 60 per cent oxygen—are prescribed,

any standard type of equipment such as mask, catheter, or tent, can be used. If concentrations higher than 60 per cent oxygen are prescribed, however, some type of mask *must* be used. One other important consideration is the patient's comfort. A patient who is comfortable and who does not fight the treatment will derive considerably more benefit than a patient who is uncomfortable and objects strenuously to the treatment. Therefore the type of oxygen equipment should be chosen for its acceptability to the patient, balanced by the clinical needs and the economic considerations.

It is beyond the scope of this booklet to set down detailed instructions for the correct operation of every kind of oxygen therapy apparatus. However, each manufacturer is vitally interested in having his particular apparatus give complete satisfaction. He therefore furnishes detailed operating instructions with each piece of equipment. *By studying these instructions and with a little practice, it is relatively simple to familiarize oneself with correct operating procedure.* Oxygen therapy can be administered at minimum cost and with maximum clinical effectiveness, if reasonable care is taken to operate the apparatus according to instructions. Keep these instructions on hand for reference.

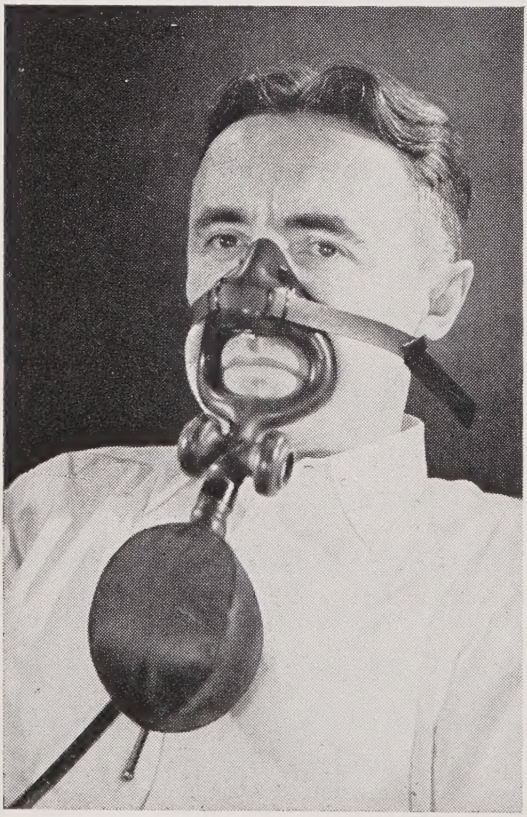
In the following discussion of the different types of apparatus, the various oxygen therapy techniques in most general use are described.

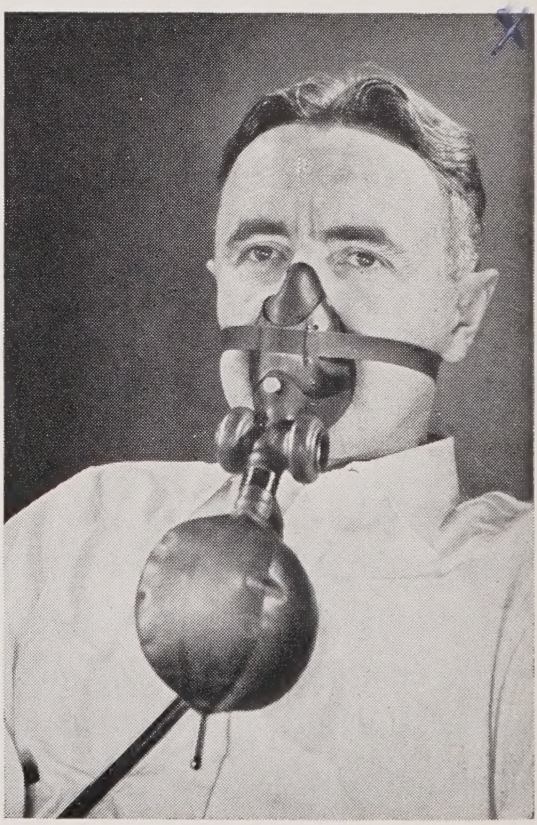
When oxygen therapy is to be administered, it is important to gain the patient's co-operation by explaining carefully what is going to be done, and to relieve any fear or anxiety that may exist in his mind. Only in this way can the maximum benefit of the treatment be obtained.

Face Masks

Oxygen therapy face masks enjoy widespread popularity because they are inexpensive, portable, and capable of administering oxygen throughout the therapeutic range, up to concentrations approaching 100 per cent oxygen. The face mask is the only type of equipment, with the exception of a special adaptation of the open-top type of tent, which will be discussed later, by which high concentrations of oxygen can be administered economically. The pictures on this page illustrate two types of masks.

There are two types and two sizes of B-L-B masks from which to choose.





The B-L-B mask permits the administration of any desired concentration up to 95-100 per cent oxygen in the inspired air. The apparatus is available in large and small sizes, in both the nasal and oronasal types. Patients who are mouth breathers, are not cooperative, or are unconscious require the oronasal type. Otherwise the nasal type will be found more comfortable as a general rule. *Choice of the correct size and type of mask is important.*

The complete mask apparatus consists of three parts: (1) the mask proper, and (2) the connecting device that joins the mask to (3) a reservoir-rebreathing bag. The B-L-B is a *partial rebreathing* mask in which approximately the first third of the expired air—the part that is highest in oxygen and lowest in carbon dioxide—is saved in the reservoir bag and rebreathed. The earlier models were equipped with a metal connecting-regulating device provided with three small portholes, one or more of which could be opened or closed to control the concentration of oxygen in the inspired air. The newer models are provided with two sponge-rubber disks that act as both inspiratory and expiratory valves.

Oxygen concentrations administered with the earlier models are controlled by opening or closing the portholes and adjusting the liter flow. For example, 4 liters per minute with two portholes open will supply the average patient with approximately 50 per cent oxygen in the inspired air. With the new models, the oxygen concentrations are controlled by the *liter flow only*. For example, 4 liters per minute will supply approximately 40 to 50 per cent oxygen; 6 liters, 50 to 60 per cent.

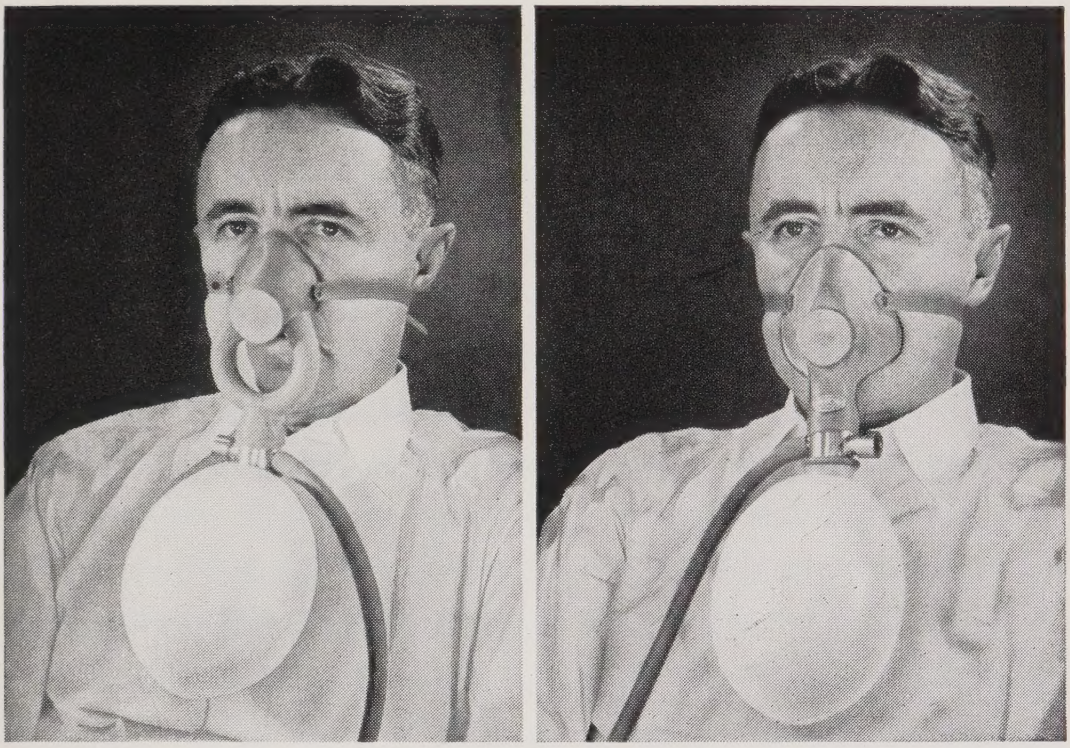
The following applies to the operation of the old as well as of the new model of B-L-B masks. When concentrations approaching

100 per cent oxygen are administered, the liter flow should be sufficiently high so that the reservoir-rebreathing bag *does not collapse completely* during the normal respiratory cycle. Most patients inhale unusually deeply once every 10 or 15 minutes. It is not necessary to adjust the liter flow high enough to prevent collapsing the bag during these occasional extra-deep inhalations.

However, the patient should be observed for about 10 minutes to be sure the liter flow is high enough for the normal respiratory depth. When lower concentrations are administered, the bag *should collapse* during each respiratory cycle. The longer the bag stays collapsed toward the end of each inhalation, the lower will be the concentration of oxygen in the inspired air.

There is a plug in the bottom of the reservoir-rebreathing bag and another plug in the front of the mask proper. The plug in the bag can be removed to drain off excess moisture. The plug in the mask is removed when a Miller-Abbott or Wangensteen type tube is used.

The O-E-M meter mask derives its name from the meter, which attaches directly to the outlet of a regulator and on which the concentration of oxygen is set. This mask is available in both the nasal and the oronasal types. The design of the mask is such that only one size is required. The operation of the O-E-M mask differs from that of the B-L-B in one important respect. *Regardless of what concentration of oxygen is being administered, the reservoir bag should never be allowed to collapse completely during the normal respiratory cycle.* In all other respects the operation of the O-E-M is similar to that of the B-L-B, except that it should not be used on a float-type flow indicator. The back pressure caused by the injector



With the O-E-M face mask, oxygen concentration is set on the meter that attaches directly to the regulator outlet.

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device in the meter is too high for this type of flow indicator to overcome completely.

Some helpful suggestions on the operation and care of B-L-B and O-E-M masks follow:

1. When using the B-L-B mask, select the most suitable size. When using either the B-L-B or the O-E-M, select the proper type, i.e. nasal or oronasal.
2. Turn on the oxygen so that it is flowing at the rate of about 6 or 8 liters per minute. Always start with an excess flow of oxygen.

3. Adjust the mask in place; pass the rubber retaining strap around the back of the head just above or just below the ears, whichever is most comfortable to the patient. *Do not make the strap too tight.* The mask should be held snugly and yet firmly against the face. Make certain air from the top of the mask does not blow into patient's eyes.

4. Many patients tend to breathe more deeply or more rapidly during the first few minutes the mask is in place. Wait until the respirations return to their former rate and then gradually adjust the liter flow to about the minimum that will maintain the desired concentration of oxygen. The required liter flow will vary with the pulmonary ventilation of each patient.

5. Every hour and a half to two hours, the mask should be removed and the patient's face should be washed, dried, and powdered before the mask is replaced. Sometimes vanishing cream is preferable to powder. This procedure is particularly important to the patient's comfort in hot weather.

6. At the end of each use, the mask, connecting device, and bag should be washed in soap and water and rinsed thoroughly before being boiled for 4 or 5 minutes. Before boiling, it is recommended that each unit be wrapped in a double thickness of gauze. Dry each part thoroughly before it is put away for future use. Unless the sponge-rubber disks of the B-L-B are dried completely, the mask will not operate satisfactorily.

The principle difference in the operation of these two masks is worth repeating: The oxygen concentration in the B-L-B is governed by the liter flow and *the breathing bag collapses at the depth*

of each inspiration except when 100 per cent oxygen is being administered. The concentration in the O-E-M is set on the meter and *the breathing bag is never allowed to collapse* regardless of the concentration.

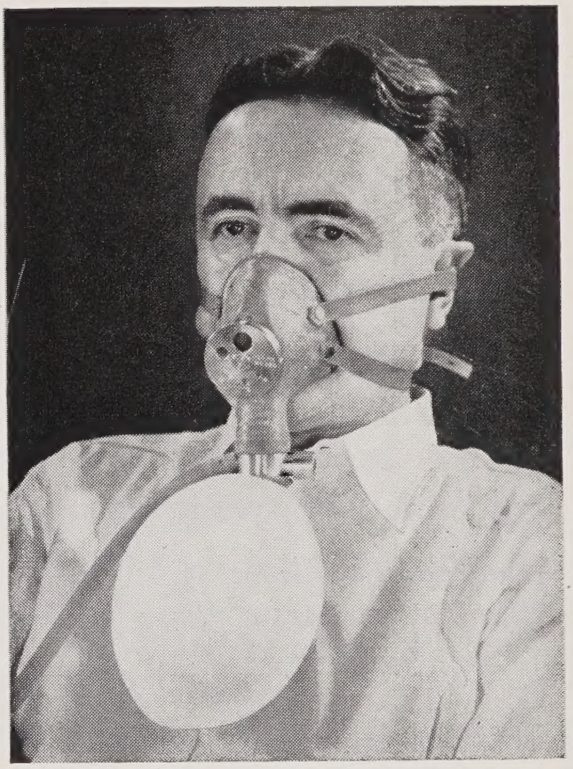
Theoretically the moisture deposited in the face-piece of a mask, from the patient's exhalations, should be sufficient to prevent any dryness or irritation of the nose or throat. However, an occasional patient, particularly when 100 per cent oxygen is being administered, may complain of dryness. If this happens, the oxygen can be humidified by passing it through a water-bottle humidifier, described later, or, if the O-E-M is being used, by introducing 20 cubic centimeters of water at a time into the meter.

As yet the maximum length of time that high concentrations of oxygen can be safely used on human beings is not known. However, when a *mask* is used, the inhalation of high concentrations of oxygen is, *in actual practice,* by no means continuous, because the patient talks, eats, or has the mask removed at rather frequent intervals for general nursing care.

Both the B-L-B and the O-E-M masks can be used to administer helium-oxygen mixtures. When used for this purpose, only the oronasal type masks should be employed. The meter of the O-E-M mask is, of course, set at 95.

Positive-Pressure Mask

At times it is desired to administer oxygen under slight positive pressure when such conditions as pulmonary edema are being treated. The special O-E-M meter mask pictured on page 28 has an attachment that makes this possible. By rotating the dial on the



This special O-E-M meter mask can be used for administering oxygen under slight positive pressure.

front of the mask, oxygen can be administered under 1, 2, 3, or 4 centimeters of water pressure. The largest opening in the disk is for administering oxygen at normal atmospheric pressure.

Intranasal Oropharyngeal Catheter

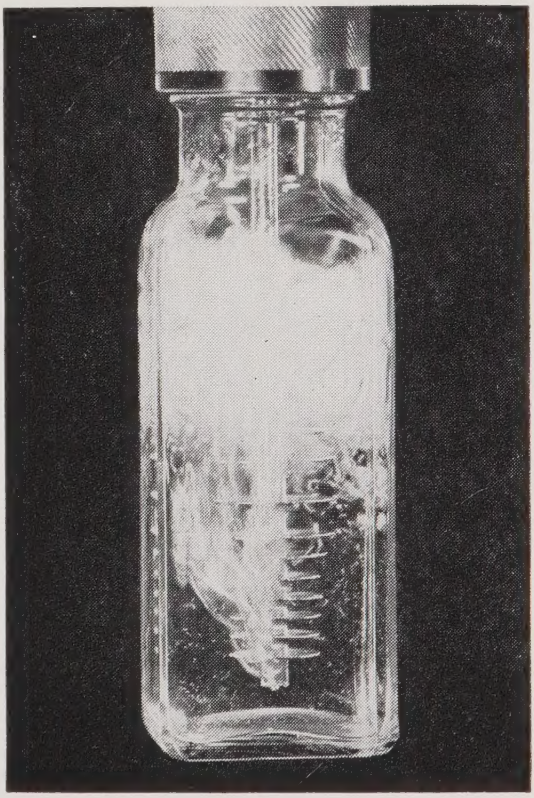
The administration of oxygen by intranasal oropharyngeal catheter differs from the administration of oxygen by other types of nasal equipment, which are discussed later, in that oxygen is delivered directly into the oropharynx. Therefore, this technique is being considered separately. Furthermore, this form of oxygen administration, although used widely, requires technical knowledge and skill for satisfactory results.

The intranasal oropharyngeal catheter permits the administration of oxygen concentrations in excess of 50 per cent. The technique involves passing the catheter tip through the nostril and into the oropharynx. Always make sure the oxygen is flowing before the catheter is inserted. Urethral catheters, No. 8 to 12 French, are the most convenient sizes to use. In order to avoid dryness and irritation of the mucous membranes, *it is important that the oxygen first*

Taping catheter on nose and forehead is more comfortable than taping it across lip and cheek.

be passed through a suitable humidifier. A humidifier breaks the oxygen stream into tiny bubbles and thus moistens the oxygen.

The end of the catheter directly adjacent to the tip should be perforated by several small holes so that the stream of oxygen will not be directed entirely in one spot on the mucous membrane. Perforation can be easily accomplished by sticking a red-hot needle or pin through the catheter wall. A catheter that has been softened by frequent boiling is better than a new one. Special catheters for oxygen therapy, made out of soft rubber with extra holes in the end and having an extra-large lumen, are available.



Oxygen is moistened by passing it through some type of water-bottle humidifier.

Large-bore rubber tubing should be used in making connections between the oxygen regulator, humidifier, and catheter. An ordinary small glass eyedropper, the tip of which has been broken off well back, makes an efficient and convenient joint between this tubing and the catheter.

Specific suggestions on the correct placing of the catheter are as follows:

1. Determine the *approximate* depth to which the catheter is to be inserted by measuring the distance from the external nostril to the tragus of the ear and marking this distance on the catheter with a small, narrow piece of adhesive tape.

2. Turn on the oxygen to about 5 liters per minute and lubricate the catheter sparingly with vaseline. Avoid the use of light oils and jellies for they are usually soluble in water and in watery solutions and soon leave the catheter dry and harsh. Be sure the discharge holes are unobstructed.

3. Most catheters have a natural "droop" that will facilitate entrance into the pharynx. The direction of this "droop" should be determined by rotating the catheter between the thumb and forefinger just before inserting it.

4. *Correct placement of the catheter has an imporatnt bearing on the amount of oxygen the patient will receive.* Some insert the catheter through the nose and into the pharynx until the tip can be seen through the mouth, hanging approximately opposite the uvula. Probably the most accurate method is to

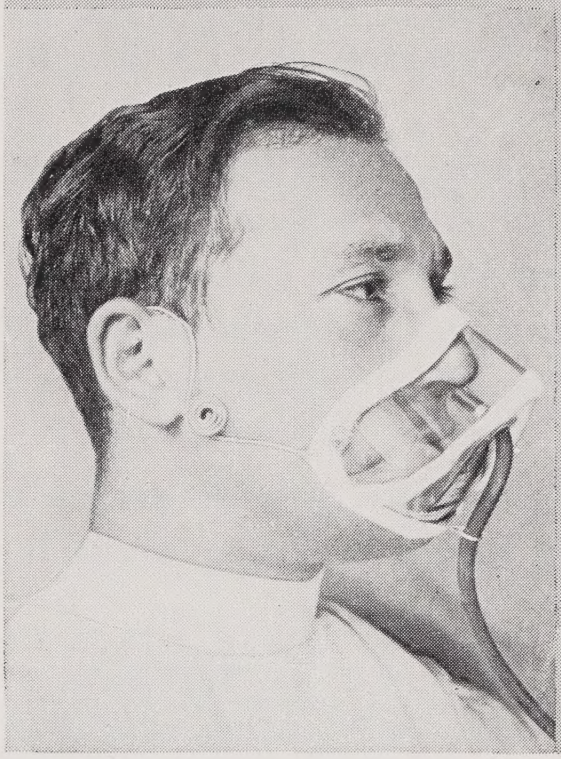
introduce the catheter beyond the measured depth until the patient is seen to swallow a bolus of oxygen and then withdraw it just to the point where swallowing is no longer observed.

5. For the correct method of fastening the catheter in place, see the illustration on page 29.
6. A clean, freshly lubricated catheter should be inserted in the alternate nostril at least once every 12 hours or more frequently if the amount of mucous secretion makes it advisable. *The catheter must not be permitted to adhere to the inside of the nose.* If irritation is present, the frequent application of a bland oil is helpful.

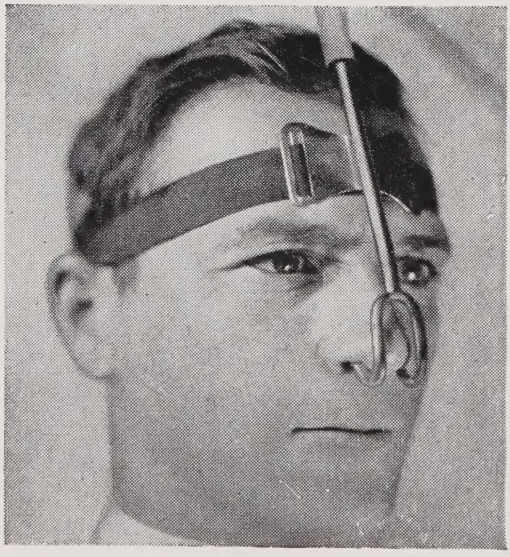
It is difficult to state what alveolar oxygen concentrations can be expected with the intranasal oropharyngeal catheter technique because the concentration depends upon placement of the catheter, the liter flow, and the patient's tolerance. Therefore, it is suggested that the most satisfactory method is to adjust the liter flow to that rate which appears to overcome the patient's symptoms of oxygen-want. This may be 5, 6, 8, or even 10 liters per minute.

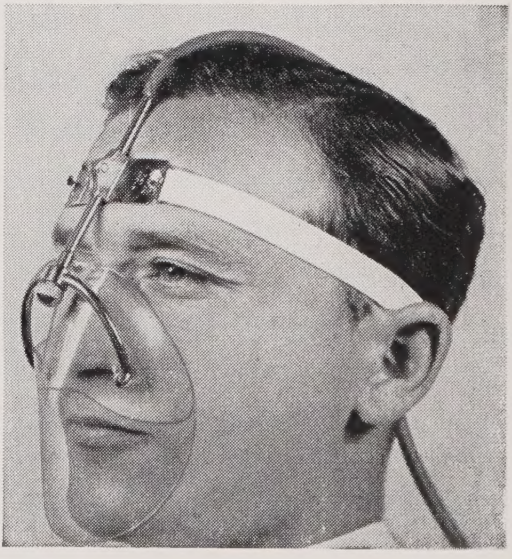
In the oropharyngeal type of administration, the catheter tip commonly rests approximately opposite the uvula.

NASAL EQUIPMENT



Various types of nasal apparatus have been designed to suit the individual preferences of the physician and patient.





If the tip of the catheter is placed only an inch or two inside the nose, it is possible to obtain only very moderate concentrations of oxygen. This should not be confused with the intranasal oropharyngeal catheter technique.

Nasal Equipment

Metal nasal inhalers, Lombard-type inhalers, nasal catheters, face tents, and other simple, inexpensive types of nasal oxygen apparatus can be used for continuous treatment or when intermittent self-administration is prescribed.

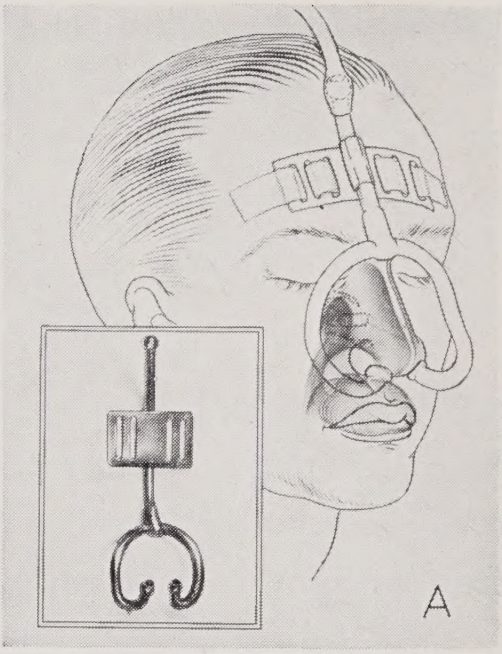
None of these devices is capable of administering, continuously, more than moderate concentrations of oxygen, but all that many patients require is an additional 15, 20, or 25 per cent oxygen in the inspired air beyond the normal 20 to 21 per cent. Therefore, it is expedient that the hospital have one or more pieces of nasal apparatus available. They may be particularly valuable in an emergency.

Metal Nasal Inhalers

Metal nasal inhalers, sometimes referred to as metal cannulas, consist of prolonged metal tubes, the ends of which are inserted a short distance into the nostrils. It is usally advisable to moisten the oxygen by means of a water bottle, of which several types are available, so as to avoid any unpleasant and irritating dryness in the nose and throat.

The metal nasal inhaler is applied to the nose so that the ends of

Metal nasal inhaler (insert, lower left) is applied as shown at right (A).



From "The Management of the Pneumonias," by Jesse G. M. Bullowa, M.D., published by The Oxford University Press.

the prongs enter each nostril ¼ to ½ inch. The forehead plate can be attached to the forehead with adhesive tape or with a head band. The prongs are of malleable metal and can be bent to fit faces of various size. Some prefer to use short pieces of rubber tubing — approximately ¾ inch long— on the ends of the prongs. *The nostrils should not be occluded* by the prongs or the patient will be compelled to breathe through his mouth to supply the tidal air. The oxygen is supplied through a flexible, thick-walled rubber tube, which should be fastened to the pillow or bedclothes back of and to one side of the patients head. The oxygen should be passed through at least 3 inches of water in an ordinary bubble bottle. This prevents dryness and irritation of the patient's nose and throat.

The average alveolar oxygen concentrations said to be obtainable with the metal nasal inhaler are: 30 per cent with an oxygen flow of 4 liters per minute; 30 to 40 per cent with 6 liters; and 40 to 50 per cent with 8 liters. Smaller inhalers are available for the treatment of children.

Oxygen Tents

An oxygen tent is a complete, portable air-conditioning unit that provides the patient with comfortable conditions of temperature and relative humidity while he is breathing the prescribed concentration of oxygen.

Specifically, an oxygen tent usually consists of a practically gas-tight fabric canopy, fully transparent or amply provided with windows, which is supported over the bed in such a way as to enclose the head and upper portion of the patient's body. Connected to this canopy is a conditioning cabinet to cool and dehumidify the atmosphere in the canopy, by circulating it through cracked ice or

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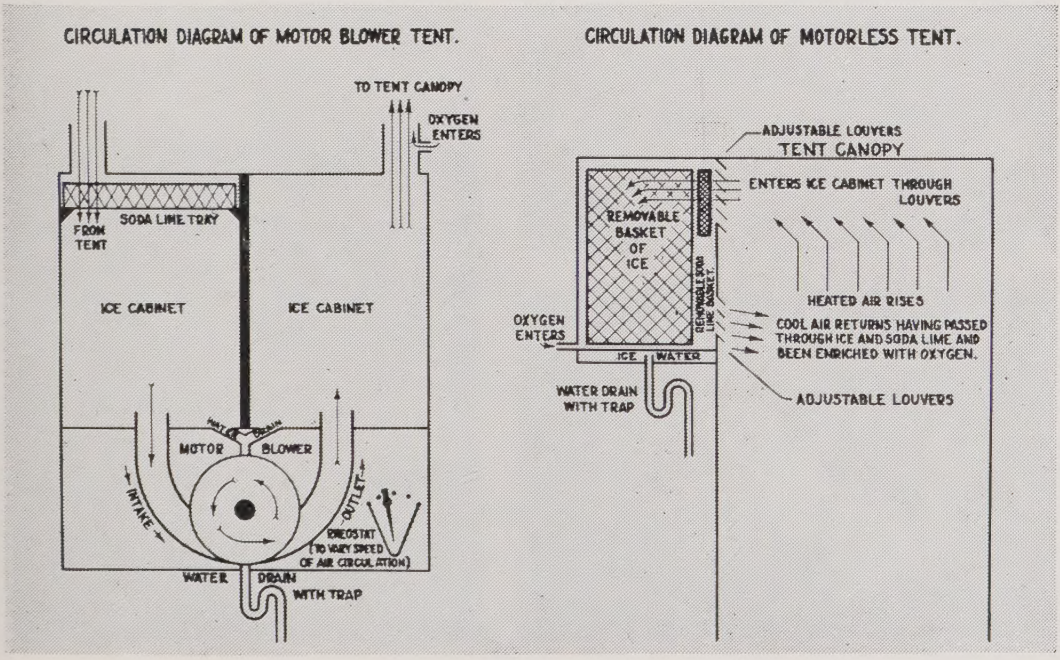
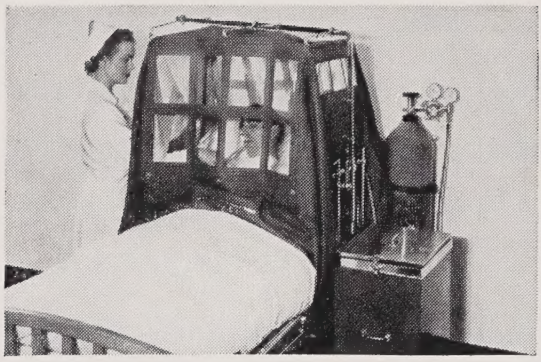
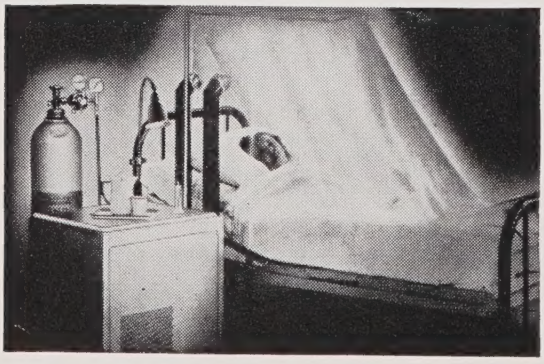
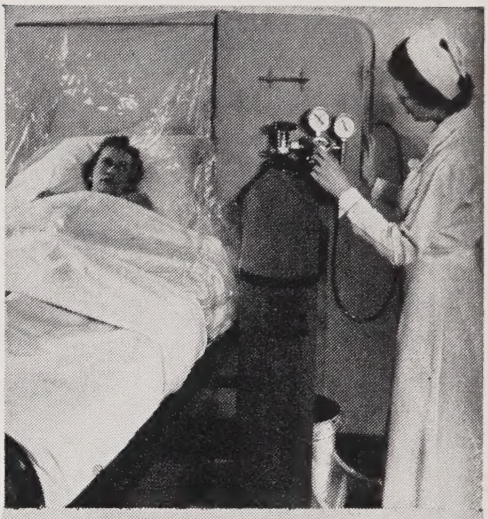
Oxygen tents can have forced or thermal circulation.



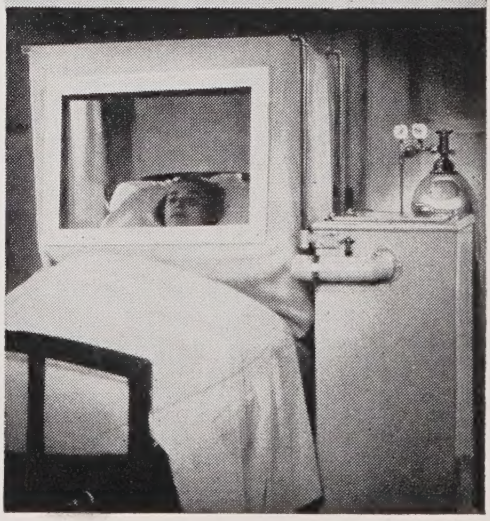






OXYGEN TENTS

Oxygen tents, many types of which are in daily use, are air-conditioning units to which oxygen is continuously added to maintain the desired concentrations.



refrigerated coils, or by passing it around a container of "Dry Ice." Oxygen is added to the circulation system at the proper rate to maintain the desired oxygen concentration under the tent canopy.

There are two methods of circulating the atmosphere in an oxygen tent. One is by use of a motor-driven blower and is known as forced circulation. The other employs the principle of warm air rising and cool air falling and is known as thermal circulation. Both have proved satisfactory and it is a question of personal preference and convenience in choosing between the two.

Every oxygen tent is accompanied by a set of operating instructions issued by the manufacturer. The instructions should be read carefully, and it is a good idea, while doing so, to practice operating the tent. This is time well spent. It will result in more effective oxygen therapy and in operating economies.

Open-Top Tents

Another type of oxygen equipment is the open-top box tent, particularly suitable for the treatment of infants and small children, but also satisfactory for adults. A therapeutic concentration of oxygen is maintained in the lower part of the box because the rate of oxygen diffusion is less than the rate of inflow. Also the oxygen, being introduced through the top of the ice cabinet, is cooled and therefore drops to the bottom of the box, setting up a thermal circulation somewhat similar to that in the standard motorless tent.

When the open-top box is being used, frequent tests should be made of the atmosphere surrounding the patients head. It is also important to *avoid room drafts,* which would increase the rate of

oxygen diffusion. When used under the proper conditions, the open-top box has found considerable favor in the treatment of small children, because it permits feeding, nursing, and medical attention without interrupting oxygen therapy.

By a simple adaptation of the open-top box, it has been found possible to administer oxygen in concentrations up to 95 per cent at a reasonably small rate of oxygen flow. The modification consists of closing the box by a rubber cover fitted snugly over the top. The apparatus is so arranged that ice for cooling can be introduced without uncovering the apparatus. Removal of carbon dioxide is accomplished by soda lime. When using the open-top box in this manner, *it is extremely important to make frequent determinations of conditions in the box such as temperature and carbon*

Nursing procedures can be simplified when open-top tents are used.

Canopies should be tucked in tightly to prevent oxygen loss.

dioxide concentration, since these conditions can change rapidly in such a small space. Furthermore, medical investigators recommend that, in order to avoid possible toxic effects when oxygen concentrations above 70 per cent are being administered, the patient be allowed to breathe room air for ½ to 1 hour following each 3- or 4-hour period of high oxygen administration.

Any oxygen tent must accomplish two objectives. One is to provide effective oxygen therapy, an important part of which is the physical and mental comfort of the patient. The second consists in attaining the first objective at a reasonable cost. Both can be accomplished only through careful and intelligent operation of the tent.

Effective Oxygen Therapy

The following suggestions should prove helpful in obtaining the maximum effectiveness:

1. Make frequent analysis of the oxygen concentration.
2. Temporarily increase the flow of oxygen each time the tent is opened, until the proper oxygen concentration is restored.
3. Carefully record on the case chart all data pertaining to the course of oxygen treatment.
4. Use a tent that operates quietly.
5. Use a reasonably large canopy with ample windows.
6. Avoid making unnecessary noise when refilling the ice cabinet or replacing empty oxygen cylinders.
7. Maintain a comfortable temperature and humidity inside the canopy.

Control of the Cost

The principal factor in reducing the cost of oxygen therapy is to prevent oxygen waste. Keep the following suggestions in mind:

1. Take proper care of equipment.
2. Support the oxygen cylinder so that it cannot be accidentally knocked over.
3. Inspect the tent canopy for holes or other sources of leakage.
4. Keep the skirts of the tent canopy tucked in tightly. A rubber sheet under the mattress also will help conserve oxygen.
5. Shut off the motor blower when refilling with ice or soda lime.
6. Do not allow the sleeves or other openings in the tent canopy to remain open any longer than is usually necessary.
7. Make frequent routine analyses of the oxygen concentration in the tent atmosphere.

One does not have to be a mechanic to run oxygen tents; they are simple to operate at a reasonable cost if three general rules are followed:

1. Follow the manufacturer's instructions.
2. Take good care of the equipment.
3. Use an oxygen analyzer.

Incubators

It is beyond the scope of this booklet to discuss the many different types of infant incubators and their various operating details. It is expected that hospital personnel will familiarize themselves with the particular type of incubator used in their hospital.

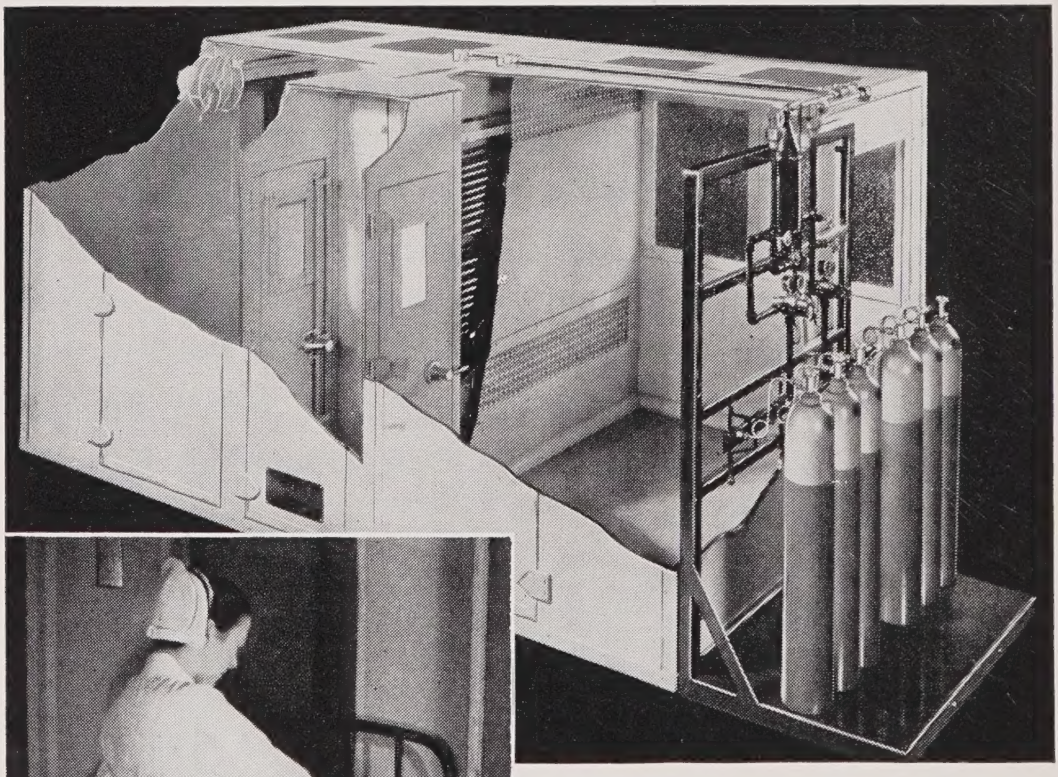
There appears to be a growing tendency on the part of physicians to prescribe oxygen for infants in incubators. Not all incubators, however, are designed for oxygen administration. Therefore, *never attempt to administer oxygen in an incubator without first making certain it is designed for that purpose.* Disregarding this rule may produce a serious hazard.

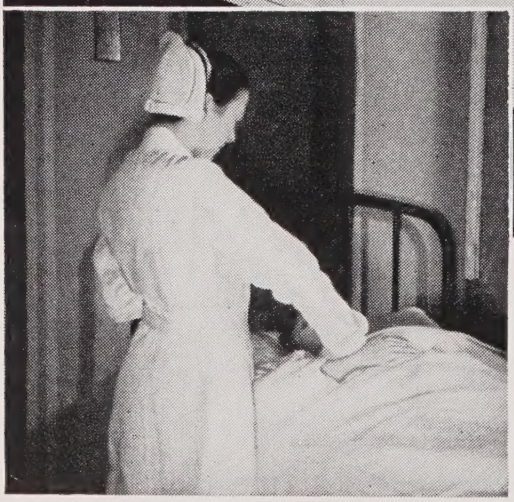
The Children's Bureau of the U.S. Department of Labor conducted an intensive study of this question and published a report, "Incubators for Premature Infants," which appeared in the American Journal of Public Health, Volume 30, No. 12, Pages 1415 to 1421, December 1940. The report was compiled by E. C. Dunham, M.D., H. C. Dickinson, Ph.D., G. J. Gowens, and J. Witters. Copies of this report, which covers some 10 or 12 different incubators, can be obtained by writing to the Children's Bureau, U.S. Department of Labor, Washington, D. C.

Oxygen Chambers

There are many advantages both for the patient and the nurse when the patient is placed in a room the entire atmosphere of which is supplied with the proper concentration of oxygen and where temperature and humidity are also controlled.

The circulation of the atmosphere necessary to assure proper conditioning is usually obtained by motor-driven blowers in suitable cabinets outside the room.





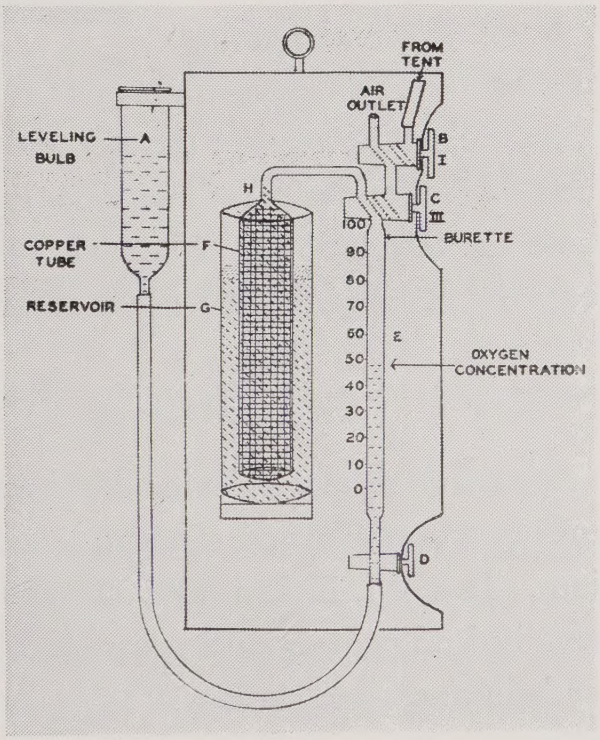
(Above) A cutaway section of a model oxygen room.

(Left) Complete nursing service under ideal conditions is possible in the oxygen chamber.

Analyzers

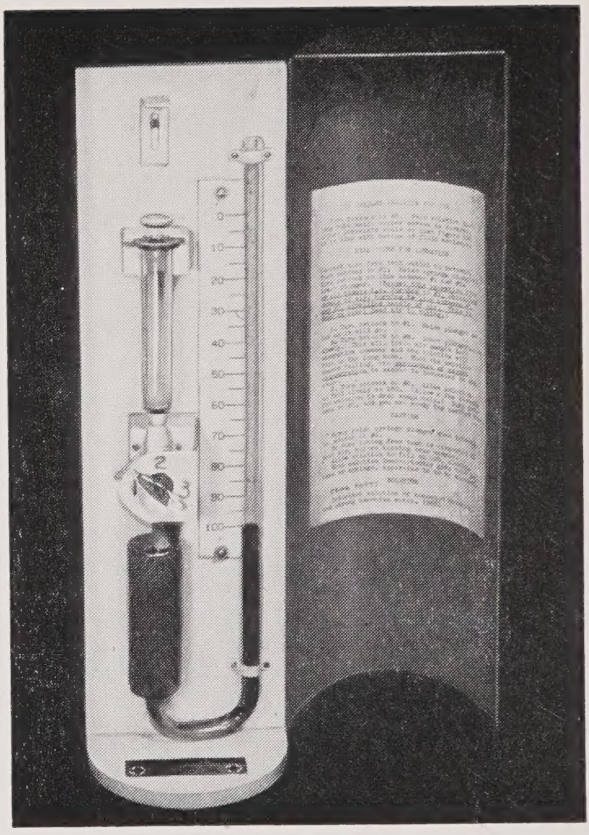
One of the most important factors in the effective and economical administration of oxygen therapy in tents and chambers is the routine use of an oxygen analyzer. *There is no way of knowing what concentration of oxygen the patient is breathing unless the atmosphere is tested with an oxygen analyzer.* Furthermore, an analyzer, properly used, will indicate when oxygen is being wasted.

Once the principle of oxygen analysis is thoroughly understood, most types of analyzers are extremely simple to operate. This principle consists in taking a known quantity, usually 10 cubic centimeters, of the atmosphere to be tested, injecting it into a pipette where all the oxygen will be absorbed from the test sample, and then measuring what remains. The difference in volume between what remains and the original sample represents the percentage concentration of oxygen. The measuring burettes or syringes of standard analyzers are calibrated directly in per cent of oxygen, so that no calculation is necessary. There are many types of analyzers available that



Concentrations of oxygen in tents and chambers should be checked periodically with an oxygen analyzer.

Analyzers are simple to operate. Readings can be obtained directly without further calculation.



work on this principle and they are usually variations of the designs illustrated here.

Carbon dioxide analyzers operate on the same principle. A different absorbing medium, of course, is used. Combination oxygen and carbon dioxide analyzers are also obtainable.

It will be found that the routine use of an oxygen analyzer at least every 4 hours will result in more effective oxygen therapy and a reduction in its cost. When there is any doubt as to the accuracy of an oxygen analyzer, test room air. If you do not obtain a reading of approximately 20 per cent oxygen, the analyzer needs adjustment or new solution.

Helium-Oxygen Apparatus

Apparatus is available for administering helium-oxygen mixtures economically and efficiently, and in any desired concentrations. The B-L-B and O-E-M types of inhalation apparatus, described on pages 23 to 27, provide conveniently portable methods for helium-oxygen therapy.

Another type of helium-oxygen apparatus involves closed-circuit rebreathing. A mouth piece or mask is used with this apparatus for short periods of administration. For more continuous use, a hood has been devised with an opening that fits snugly about the neck. The atmosphere is cooled, dehumidified, and the exhaled carbon dioxide is absorbed.

When this type of apparatus is used, it is important that a technician be in attendance continuously and that leaks be prevented. A small liter flow of the helium-oxygen mixture is sufficient to maintain a constant percentage of the respective gases in the circuit. This equipment can also be used to administer oxygen or helium-oxygen mixtures under slight positive pressure (1 to 5 centimeters of water).

The helium-oxygen mixtures in most common use are either 20 or 25 per cent oxygen and 80 or 75 per cent helium. It is customary to use a cylinder containing the desired helium-oxygen mixture and a separate cylinder of straight oxygen. The cylinder of oxygen makes it possible to switch the patient from the helium-oxygen mixture to straight oxygen when it is desired to do so. *Never use a cylinder containing only helium because if the oxygen supply should become exhausted, there is a possibility of the patient's breathing pure helium . . . with obviously injurious results.*

Oxygen Therapy Rental Services

The problem of supplying oxygen in private homes to cardiacs, severe migraine sufferers, hay-fever and asthma victims, and others who have some chronic respiratory or circulatory condition is becoming more and more important. Today most cities have rental

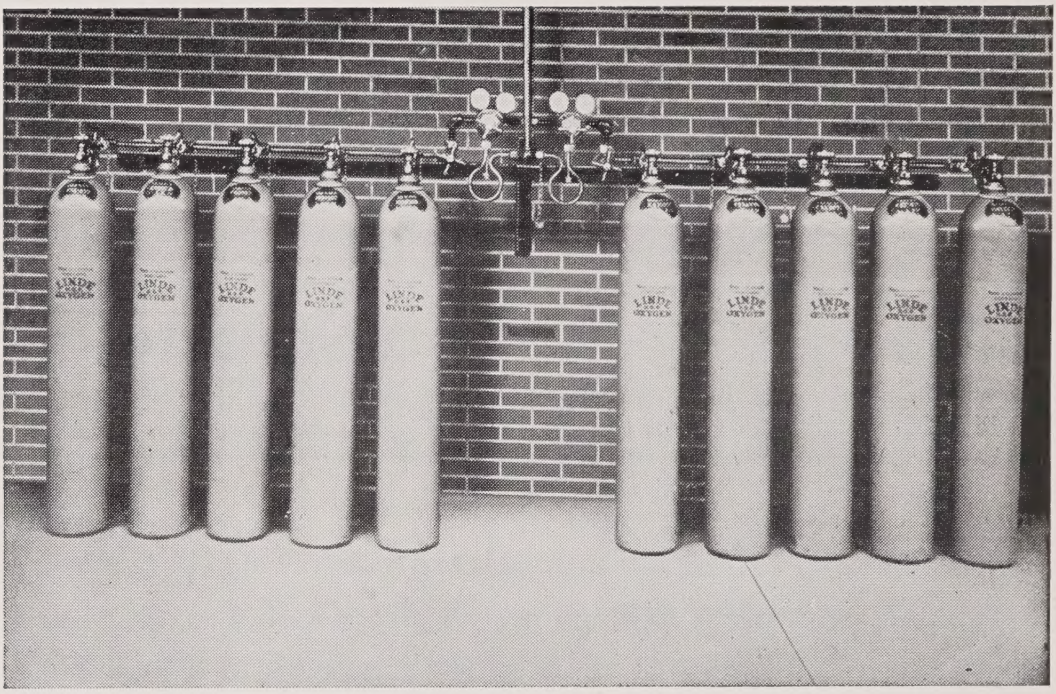
concerns that make a business of renting oxygen therapy apparatus and supplying the necessary oxygen to patients in private homes. These service companies are on call 24 hours a day; they furnish complete service and have trained technicians to carry out the physician's instructions. Occasionally, too, hospitals have more oxygen cases than they have equipment to treat. In such instances, the local rental service can be called upon to provide extra equipment temporarily. Thus, the oxygen therapy rental company performs an important service in the area in which it operates.

Hospital Piping Systems

An increasing number of hospitals are recognizing the economy, convenience and safety to be gained by the installation of a central supply system for oxygen for routine therapeutic use. Such a system saves considerable handling and transportation of cylinders about the hospital and avoids any noise and disturbance caused by changing cylinders at a patient's bedside.

In such a system, oxygen cylinders are connected together, at some convenient point in the hospital, by means of an oxygen manifold which can be made to accommodate any desired number of cylinders. From this manifold, oxygen at low pressure is piped to wall outlets conveniently located in rooms and wards throughout the building. From these outlets, oxygen can be administered therapeutically by any chosen type of equipment, such as masks, tents, or catheters.

The type of manifold used is of duplex construction, having its control regulators in the center. Each side of the manifold accommodates an equal number of cylinders. If desired, both sides can be operated simultaneously, but it is customary to use oxygen from

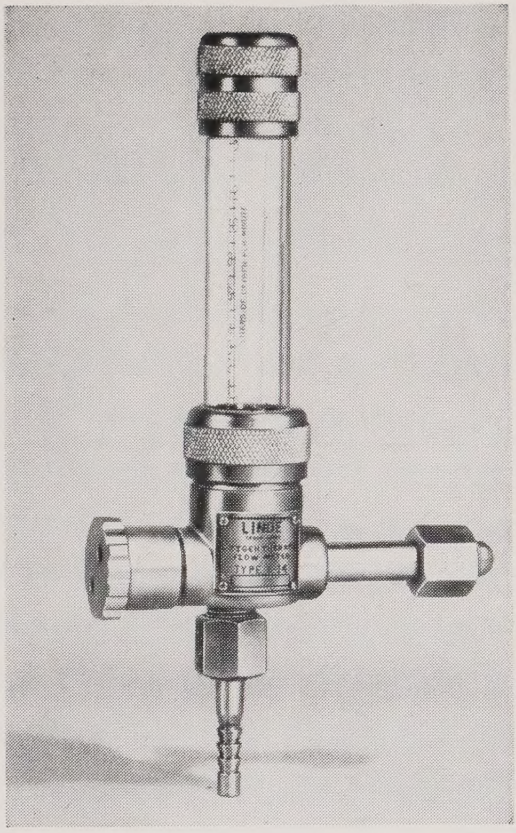


This 10-cylinder manifold installation supplies oxygen to a hospital piping system.

one side, allowing the other to act as a reserve. This reserve side will automatically start delivering oxygen to the piping system as soon as the oxygen in the active side is exhausted down to the established pressure line. This assures a constant supply of oxygen at a predetermined low pressure to the wall outlets at all times.

The experience gained by engineers of The Linde Air Products Company in similar problems of this type is available to hospitals planning such installations.

As has been stated, the oxygen is delivered through the piping system to the wall outlets in the rooms and wards at low pressure. Therefore a standard pressure reducing regulator is not necessary at these wall outlets. The Type L-14 Linde oxygen therapy flow-



The Linde oxygen flowmeter, Type L-14, can be attached to pipeline outlets or to the outlet of a welding regulator to indicate oxygen flow.

meter is ideal as a flow indicator to be attached to pipeline outlets when oxygen is to be administered.

However, the installation of a piping system does not eliminate the possibility of using standard oxygen regulating equipment that a hospital may already have on hand, or that it may purchase at some time in the future. These regulating devices can be used on the wall outlets of the piping system, but because of the low pressure already existing in the system, their primary function will be only to indicate the flow of oxygen being delivered.

Emergency Oxygen Therapy

It is possible that emergencies will arise that will make it necessary for hospitals to administer oxygen to large numbers of patients on short notice. Fortunately, as pointed out in the chapter on Oxygen Supply, oxygen can be obtained from the nearest welding shop, automotive repair shop or from practically any type of industrial plant in an emergency.

Standard welding-type oxygen regulators can be obtained from the same shops where emergency oxygen is available. These regulators reduce and control the pressure of the oxygen in the cylinder. They do not, however, measure the flow of oxygen in liters per minute and for this reason *should not be used for nasal catheter administration*. On the other hand, they can be made to serve the purpose by the use of a little ingenuity.

It has been shown how the flow of oxygen from a welding regulator can be controlled and measured by the use of the Linde oxygen therapy flowmeter Type L-14 (see page 19). A needle valve or other restriction at the outlet of the welding regulator will reduce the flow of oxygen. In some instances it is possible to obtain a satis-

factory flow of oxygen by setting the needle on the low-pressure gauge dial as near zero as possible and yet have oxygen flowing through the regulator. The low-pressure gauge is the gauge farthest from the cylinder valve when the regulator is attached to a cylinder. *Never use this system for nasal catheter administration.*

In connection with suitable apparatus for the emergency administration of oxygen, it is well to remember that basal metabolism machines, gas anesthesia machines of all types, resuscitators, and inhalators can be adapted for oxygen therapy. If none of these devices is available or if still more apparatus is needed, it is a relatively simple matter to fabricate face masks of cardboard, old X-ray film, or even heavy paper. These masks should be satisfactory if a sufficiently high flow of oxygen is delivered to the mask to cause a slight leakage around the patient's face. This slight leakage is an indication that the patient is receiving an adequate amount of oxygen and it also serves to wash out excess carbon dioxide. It is possible to administer oxygen to several patients from one cylinder of oxygen and one welding-type regulator by employing a system of pipe or tubing, Y connections, needle valve outlets, and other equipment.

If a hospital wishes to prepare itself for the emergency administration of mass oxygen therapy, it is suggested that a member of the staff be appointed to investigate this matter and determine how best to go about it.

Safety Practices

Always remember: Oxygen will not burn, but it supports combustion; that is, it readily combines with other substances and causes them to burn. Materials that combine easily in this manner with oxygen are called "flammable" or "combustible" materials. Therefore, oxygen cylinders should not be stored with flammable or combustible materials, such as oil, grease, gasoline, matches, or alcohol.

Oxygen in therapeutic concentrations is used in the presence of such combustible materials as sheets, pillow cases, mattresses, and clothing. It is extremely important to prohibit all sources of ignition, such as open flames, any electrical device including call bells, or smoking, where oxygen is being administered. All oxygen equipment should be labeled conspicuously to that effect.

Special care should be taken to warn repeatedly by sign and spoken word against the use of matches, open flames, or anything that might cause a spark in the room or tent where oxygen in high concentrations is being used. Patients should be carefully searched before being placed in oxygen rooms or tents and also after visitors have been in to see them, to be certain that they have no matches, cigarettes, or other flammable materials, or that none

have been supplied to them. Visitors should be warned to observe these safety regulations. Make sure that no X-ray apparatus or similar device is carried into the oxygen room. Electric heating pads should not be used in oxygen rooms or tents. Use hot-water bottles instead. Patients should not be rubbed with oil, alcohol, or any readily ignitible substance while in an oxygen room or tent.

Soda Lime

Soda lime is used to absorb the carbon dioxide exhaled by the patient. It must be employed when operating an oxygen chamber that is comparatively airtight at all times, unless as an alternative the oxygen flow is increased to the point where it will wash out excessive carbon dioxide. This also has the effect of removing body odors. Many times, in operating an oxygen tent, it has not been found necessary to use soda lime because the excess carbon dioxide is washed out through unavoidable leakage. However, where a rubber sheet is placed under the mattress and the tent canopy is kept tucked in securely so that a therapeutic concentration of oxygen can be maintained with a low rate of flow, soda lime may have to be used. To guard against excessive accumulations of exhaled carbon dioxide and to check the efficiency of the soda lime, it is most important to use a carbon dioxide analyzer.

Activated carbon may be used to remove odors.

Conclusion

It is hoped that this booklet may be helpful in giving a more precise knowledge of oxygen therapy apparatus and its economical operation. The Linde Air Products Company will gladly supply more detailed information on the technical phases of this subject to the medical profession and to hospital personnel who desire it.

Motion Picture

A motion picture, "Current Practices in Operating Oxygen Therapy Equipment," based on the subject matter contained in this Handbook, presents in an informative, as well as an interesting manner, the mechanical and safety aspects of modern oxygen therapy. The film has been approved by The Committee on Medical Motion Pictures, American College of Surgeons. It depicts the correct method of operation and care of oxygen therapy equipment as practiced in the leading hospitals throughout the country. Included in the two reels of the film are descriptive scenes portraying the use of catheters, face masks, oxygen tents, and oxygen chambers. Animated drawings are used to explain operating principles clearly. The film requires about 35 minutes to show.

Arrangements for showing this film can be made through any

District Office or through The Linde Air Products Company, 30 East 42nd Street, New York 17, N. Y. Arrangements should be made well in advance of the date of the showing so as to avoid conflicts with other scheduled showings.

Available Literature

From time to time articles covering the more recent work on oxygen therapy are reprinted from the medical journals in which they appeared. These reprints are available to members of the medical profession and others who are interested in the subject, and may be obtained without obligation by writing to The Linde Air Products Company, 30 East 42nd Street, New York 17, N. Y.

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